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datron
ELECTRONICS LIMITED

OPERATING MANUAL
for
DATRON 1041/1051 DIGITAL VOLTMETER

HURRICANE WAY
NORWICH AIRPORT INDUSTRIAL ESTATE NORWICH NR6 6JB ENGLAND

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OPERATING MANUAL
for
DATRON 1041/1051 DIGITAL VOLTMETER

(for calibration and maintenance procedures
refer to the servicing manual)

Instrument Designed and Manufactured by:

DATRON ELECTRONICS LTD.
HURRICANE WAY,
NORWICH AIRPORT INDUSTRIAL ESTATE,
NORWICH, NR6 6JB.

Telephone: (0603) 404824

850010 Issue 7

Due to our policy of continuously updating our products, this manual may contain minor differences in specification, components and circuit design to the instrument actually supplied. Amendment sheets precisely matched to your instrument serial number are available on request.

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SECTION 1

GENERAL DESCRIPTION

1.1 INTRODUCTION

The 1041/1051 multi-function digital voltmeters are high precision measuring instruments featuring exceptionally high stability and full systems capability. The main frame, providing full DC measurement capability can accept one of the two available true RMS AC converters and a 4-wire resistance measurement converter.

FIG. 1.1 1041 DIGITAL VOLTMETER

1051 DIGITAL VOLTMETER

1.2 FUNCTIONS AND FACILITIES

The digital voltmeter comprises a fully floating isolation amplifier with electronically switched gain ranges which provides an output for conversion to a digital reading. This reading may then be converted to BCD format and made available via the BCD output option. The true RMS AC converter options convert AC signals to DC and apply these to the analog to digital conversion circuits. The resistance converter option passes a known precision current through an unknown resistance and the DC voltage thus developed is measured. The sample and read functions of the voltmeter may be commanded by an external controller and all functions may be remotely selected to ensure system compatibility.

1.3 GENERAL ELECTRICAL DESCRIPTION

For a detailed electrical description, maintenance and repair procedures, component lists and circuit diagrams, refer to the appropriate Servicing Manual (850015-1041, 850016-1051).

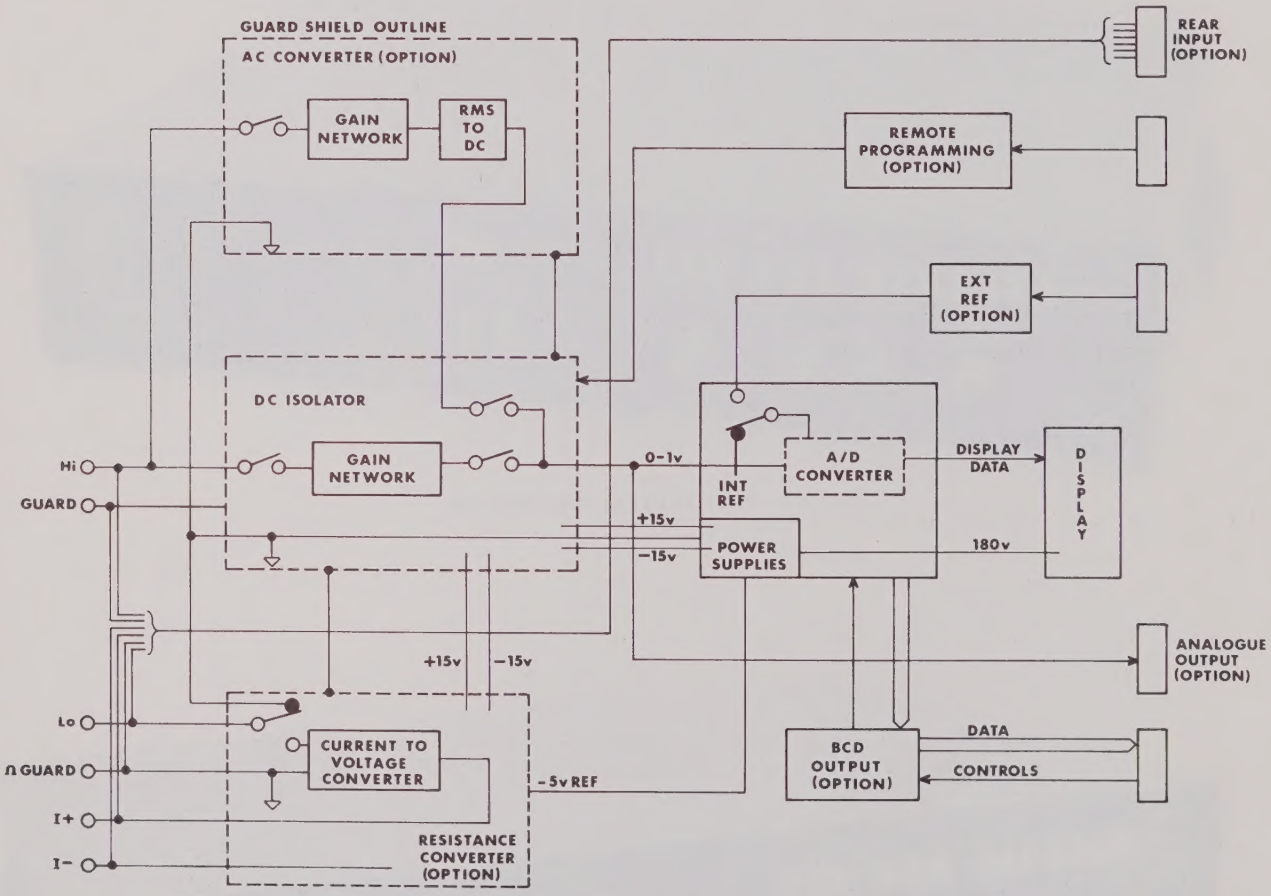


FIG 1.2 DVM SIMPLIFIED BLOCK DIAGRAM

The analog to digital conversion technique used converts the signal from the DC Isolator into a time period directly proportional to the input voltage. The DC Isolator output is a 0 to 1V signal which is amplified by a factor of 5 and then applied via electronic switching to the input of a high-gain integration amplifier. The integration capacitor starts charging from a zero state at a rate proportional to the input voltage. The integration period lasts for approximately 20mS during which time the capacitor acquires a charge proportional to V_{in}.

At the end of 20mS, a 5 volt reference signal of opposite polarity to that of the input signal is applied and the length of time it takes to discharge the capacitor to zero volts is directly proportional to V_{in}. When the voltage across the capacitor reaches zero a Null Detector produces a signal to strobe the display circuitry, disconnect the reference voltage and reset the circuit ready for the next measurement cycle.

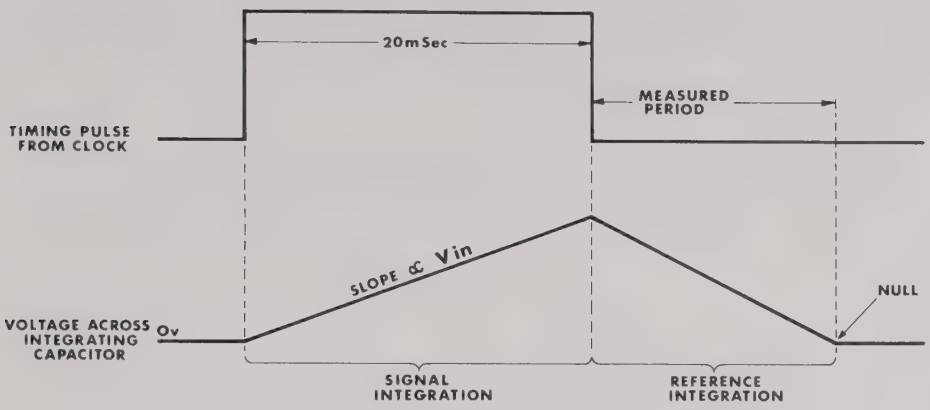


FIG 1.3 MEASUREMENT CYCLE TIMING

1.4 OPTIONS

1.4.1 True RMS Converters (Options 01 and 11)

Option 01 is a very high accuracy 5 range (1051)/6 range (1041) true RMS converter.

Option 11 is a medium accuracy 4 range true RMS converter.

1.4.2 Resistance Converters (Options 02 and 03)

Option 02 (1041 only) and Option 03 (1051 only) are resistance converters providing 4-wire measurements from .001Ω resolution to 19.999 MΩ (1041) or to 19.9999 MΩ (1051).

1.4.3. Remote Programming (Option P01)

Option P01 is an isolated remote programming facility enabling all ranges and functions to be selected remotely via TTL logic levels.

1.4.4 BCD Outputs (Options BO1, BO1a, BO2, BO2a and BO4)

Options BO1 and BO1a are electrically isolated BCD outputs giving indications of reading, range and function and allow external control of the A-D converter.

Options BO2 and BO2a (1041) and Option BO4 (1051) give the same information as Option BO1 but as they have 3-state outputs a single input may be grounded to completely disable all outputs.

1.4.5 Rear Input (Option R01)

Option R01 accepts a rear input via a 7-way connector wired in parallel with the front panel terminals.

1.4.6 External Reference (Options R02, R03, R05, R06)

Option R02 (1041) accepts a +ve external reference, 1V range, 4-wire input from a connector mounted on the rear panel to provide a ratio measurement capability.

Option R03 (1051) accepts a +ve or –ve external reference, 1V range, 4-wire input from a connector mounted on the rear panel, providing a 4-quadrant measurement capability.

Options R05 (1041) and R06 (1051) perform the same functions as R02 and R03 respectively except that the external reference ranges of both 10V and 100V are provided.

1.4.7 Analog Output (Option A01)

Option A01 provides a DC output voltage of 1V for any full range voltage input.

1.4.8 Fast Read Rates (Options F01 and SF1)

These options are available for the 1041 only.

Option F01 increases the maximum read rate capability to 20 readings/sec.

Option SF1 increases the maximum read rate capability to 150 readings/second at full range, (120 readings/sec at full scale) with 3½ digit (i.e. 1.999) resolution. This option is only fitted in conjunction with B01 and F01.

1.4.9 I.E.C. Interface Bus (Options IB01 and IB04)

These options make the 1041 and 1051 compatible with the I.E.C. standard interface bus.

SECTION 2

INSTALLATION AND SWITCH-ON

2.1 UNPACKING AND INSPECTION

Note: Should the equipment have been subjected to excessive mishandling in transit, the fact will probably be visible as external damage to the shipping carton. Unpack the equipment and check for external damage to cases, pushbuttons, terminals, etc. If any damage is found notify the carrier immediately.

Every care is taken in the choice of packaging materials to ensure that your new equipment will reach you in perfect condition. The packaging and protection are adequate to cater for all the normal hazards of road or rail transit. Special export packaging is provided for overseas orders.

2.2 INSTALLATION

The instrument is housed in a robust, heavy-gauge aluminium case designed to withstand the rough knocks of industrial usage. Detachable supply leads, comprising two metres of 3-core PVC sheath cable permanently moulded to a fully-shrouded 3-pin cable socket, fit at the rear of the instrument and should be pushed firmly home. The supply lead should be connected to a 3-pin plug (fused 1 amp), ensuring that the instrument case is earthed via the Yellow/Green earthing wire.

2.2.1 Voltage Tappings

The instrument is packed ready for use with 205V to 255V, 48 to 440Hz supplies unless otherwise specified at the time of ordering. For operation from supplies in the range 105V to 127V, 48 to 440Hz, it is necessary to alter the connections to the primary windings of the main transformer.

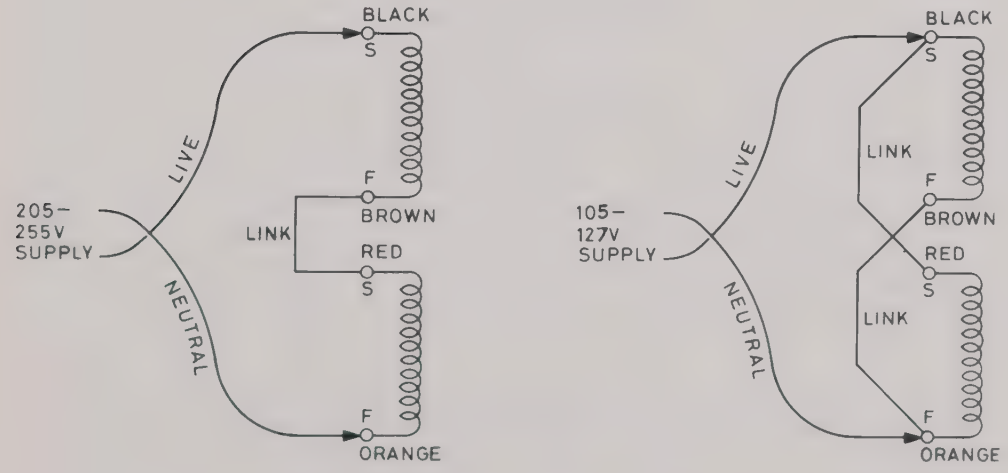


FIG. 2.1
Mains transformer tappings

To change the working voltage, remove the top cover of the instrument and locate the mains transformer in the right hand rear corner of the instrument.

For 205V to 255V operation the Red and Brown wires are connected to a linking post located between the LIVE (Black) and NEUTRAL (orange) posts.

For 105V to 127V operation the Red wire is connected to the post with the Black wire (LIVE) and the Brown wire is connected to the post with the Orange wire (NEUTRAL).

2.3 SWITCH–ON

(i) Ensure that the instrument is correctly adjusted for the mains supply to which it is to be connected. Unless otherwise specified on order it will have been connected for 205V-255V working. If in doubt check as described in Section 2.2.1.

NOTE: No fine tapping adjustments are required for voltages within each of the major ranges.

(ii) Connect the mains supply lead.

(iii) Switch on the supply and allow the equipment to stabilise. A minimum of 2 hours warm-up should be allowed to reach full specification although the instrument will be operational within a few seconds.

(iv) Before proceeding any further, read Section 3, CONTROLS AND CONNECTIONS and Section 5, OPERATION AND APPLICATIONS.

SECTION 3

CONTROLS AND CONNECTIONS

3.1 INTRODUCTION

This section details the manual and remote facilities of the 1041/1051 DVM's.

3.2 FRONT PANEL

The locations of the front panel controls are shown in Fig. 1.1.

3.2.1 Power and Control

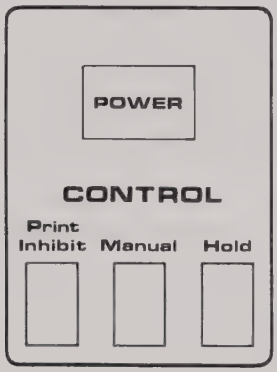


FIG 3.1 POWER & CONTROL

POWER – A push button switch with alternate on/off action mounted in the centre of the front panel. It isolates the mains supply live from the instrument with the exception of the mains fuse, socket and filter which remain live unless the supply lead is disconnected.

HOLD – A push on/push off type switch which when released allows normal free running of about 3 readings per second and when depressed disables the internal read commands. When this button is depressed, any conversion in progress is completed and displayed, the display being held until HOLD is released or a read command is initiated either via the BCD connector or via the MANUAL push button. This HOLD function may also be controlled externally via the BCD connector.

MANUAL – A momentary action push switch enabled by the HOLD button being depressed. A single reading is then taken when this button is depressed.

If the Instrument is in the Auto-range mode then upon receipt of a single manual command it will range, inhibiting the print command until the correct range is reached. A print command is then generated and no more readings taken until MANUAL is again depressed. This function may be controlled externally as COMMAND via the BCD connector.

PRINT INHIBIT – A push on/push off switch which, when depressed holds the print command signal of the BCD output low to arrest any print action. It also forces all the BCD outputs to their high impedance (OFF) states (not in Option B01) and disables the command control inputs.

This function may also be controlled externally via the BCD connector.

Front panel operation of these three switches may be inhibited via the BCD connector by use of the FP OVERRIDE control signal.

3.2.2. **Function Controls**

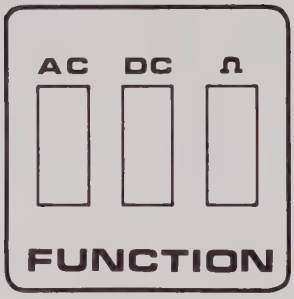


FIG 3.2 FUNCTION CONTROLS

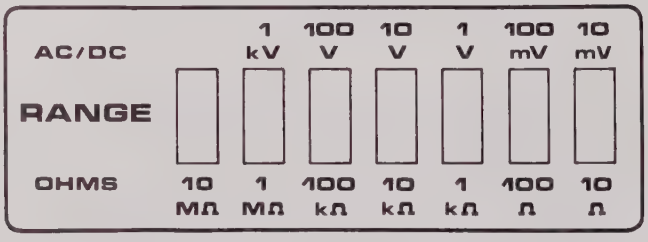
DC – A push on switch interlocked with AC and Ω which, when depressed, selects DC measurement.

AC – A push on switch interlocked with DC and Ω which, when depressed, selects AC measurement. If this option is not fitted this switch is mechanically disabled.

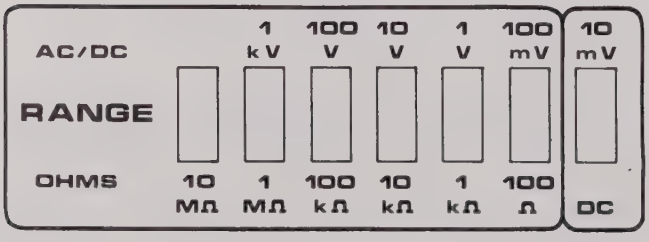
Ω – A push on switch interlocked with DC and AC which, when depressed, selects resistance measurement. If this option is not fitted, this switch is mechanically disabled.

If all three switches are released, the instrument assumed that DC is selected. External selection of the function is available via the Programming Option if this is fitted, and an indication of the selected function is supplied via the BCD connector.

3.2.3 **Range Controls and Display**

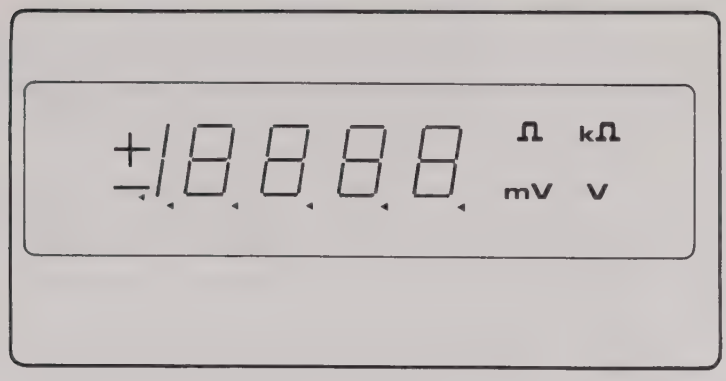


1041 RANGE CONTROLS

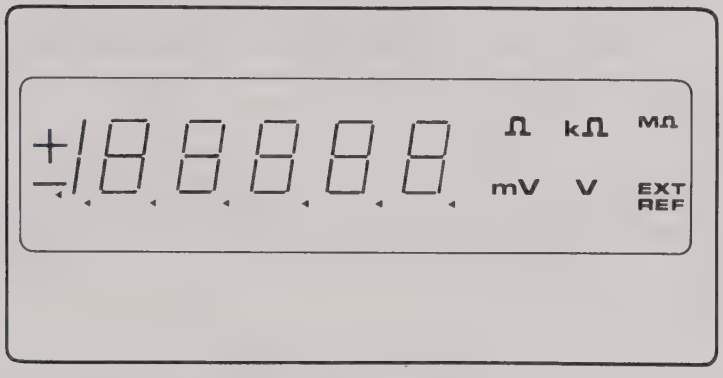


1051 RANGE CONTROLS

FIG 3.3 RANGE CONTROLS



1041 DISPLAY



1051 DISPLAY

FIG 3.4 DVM DISPLAYS

The range controls comprise a set of seven interlocked switches as shown in Fig. 3.3. They are marked with the full range value. A corresponding indication of the range selected is displayed with the value measured except in the 1MΩ range when the display is 1000.0 (0) kΩ. The 10MΩ switch is only valid when Ω function is selected and on the 1041 10MΩ is displayed as 10000kΩ.

OVERRANGE is signified by a 1 being illuminated at the left of the normal display. 100% overrange permits a maximum display of 19999(9) except on the 1kV range where it is limited by a maximum input voltage of 1000.0(0) Volts.

OVERLOAD results in blanking of the display when the measured value exceeds 100% overrange. The function symbols remain illuminated.

On the 1051 DVM the 10Ω range is unspecified and the 10mV range specified only on DC voltage and is not included in the AUTO mode.

External selection of the range is available via the programming Option if this is fitted and indication of the range selected is supplied via the BCD connector.

3.2.4 Mode Controls

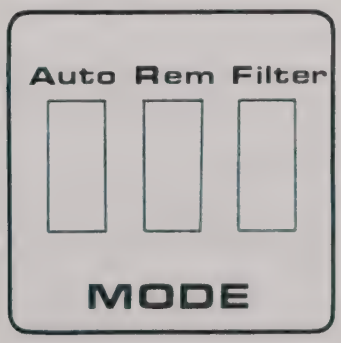


FIG 3.5 MODE CONTROLS

AUTO – A push on/push off type switch which when depressed enables the instrument to automatically select the range which gives the most accurate display. The DVM ranges up to a less sensitive range if a reading results in OVERLOAD and ranges down if the result is less than 10% of the nominal range. It automatically stops on the highest or lowest range applicable to the function selected. When released this switch enables the instrument to follow the range selected by the range buttons.

REMOTE – A push on/push off type switch which, when depressed, disables all the range, function and other mode switches. Remote programming controlling the above is then enabled if this option is fitted. Indication of the selection of this mode is provided via the programming option connector.

FILTER – A push on/push off type switch which, when depressed, increases the series mode AC noise rejection when measuring DC volts or resistance and enables AC measurements to be made down to 40Hz. It also slows down the response time and whilst the internal read rate remains the same auto-ranging commands are internally delayed to allow for the increased settling time.

External selection of FILTER is available via the programming option if this is fitted and indication of the selection of AUTO or FILTER is supplied via the BCD connector.

3.2.5 **mV Offset**

A screwdriver operated multi-turn preset control to enable the instrument to be adjusted for zero input signal applied to the 10mV range. Its range is approximately ± 80 μV and it can thus be used very effectively to compensate for external offsets as well as the very low, long term zero drift of the instrument.

3.2.6 **Input Connections and Controls**

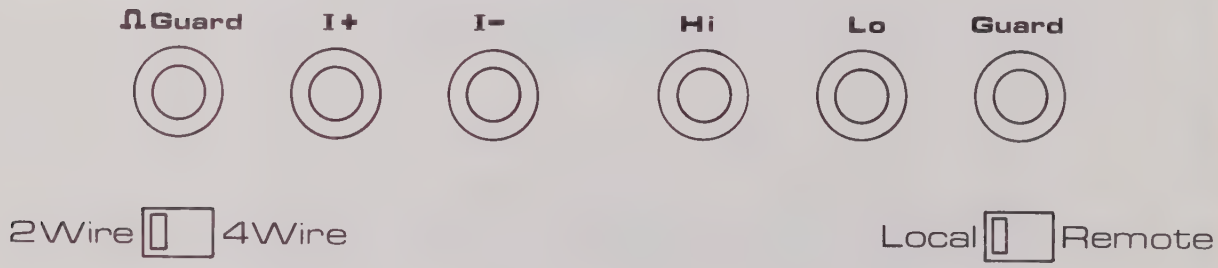


FIG 3.6 INPUT CONNECTIONS & CONTROL

Six input terminals are located on the front panel. The six input connections are Hi, Lo, GUARD, I+ (Ohms current positive), I– (Ohms current negative) and Ω GUARD. They are mounted at standard 0.75 inch (19mm) spacing and accept 4mm single or double banana plugs.

In order to minimise thermal EMF, copper wire should be used connecting the instrument and preferably passed through the side entry holes of the Hi and Lo terminals.

2 wire/4 wire – a slide switch which, when in the 2 wire position connects Hi to I+ and Lo to I–.

NOTE: Thus when 2-wire selected any voltages applied to Hi and Lo appear at I+ and I–, which could therefore be at a high potential.

GUARD LOCAL/REMOTE – a slide switch which, when in the LOCAL position connects GUARD internally to Lo (to Ω GUARD when in OHMS).

Details of the use of these switches and modes of measurement are given in Section 5.4.

Ω GUARD is internally connected to LO in voltage measurement and thus on no account may power be applied between the two. For the same reason power should not be applied between the terminals connected together by the slide switches when they are closed.

i.e. Do NOT apply any power between:–

Hi to I+)
Lo to I–) when 2 wire operation selected.

GUARD to Lo when LOCAL selected.

GUARD to Ω GUARD when LOCAL Selected and OHMS.

Ω GUARD to Lo when voltage measurement selected.

When using the front panel inputs, the following voltages must not be exceeded:–

Hi to Lo	1000 Volts DC or RMS or 1500 Volts peak.
Lo to GUARD	250 Volts peak.
GUARD to EARTH	500 Volts peak.
I+ to I– to Lo	250 Volts DC or rms.
I+ to I– to Ω GUARD	250 Volts DC or rms.
I+ to I–	250 Volts DC or rms.

3.3 REAR PANEL

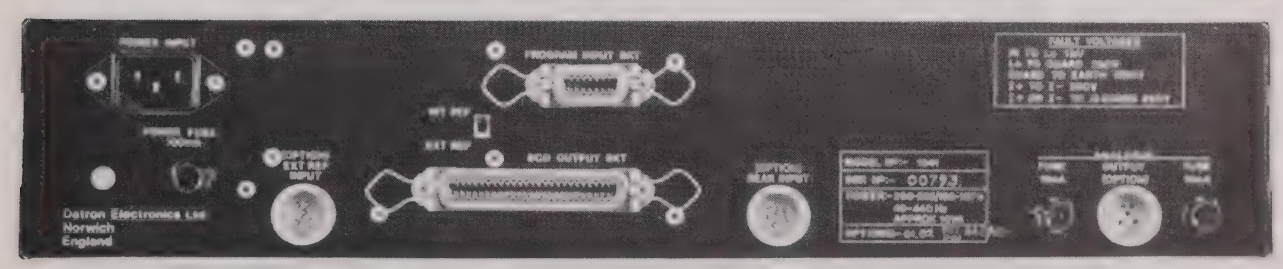


FIG 3.7 DVM REAR PANEL

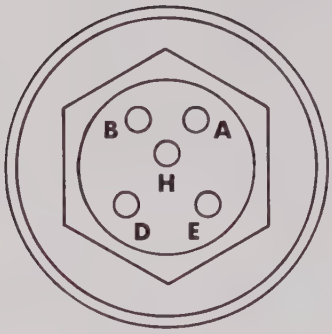
3.3.1 Power

POWER SOCKET – A 3 pin CEE regulation 250V, 6A power socket accepts the mating plug which is integrally moulded with the power lead.

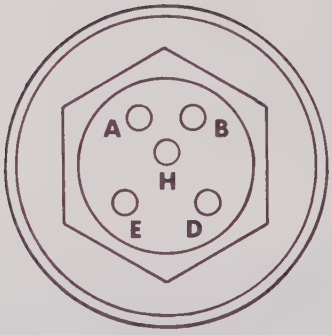
POWER FUSE the supply to the mains transformer primary windings is protected by a 20mm x 5mm glass cartridge, anti-surge type fuse; 160mA rating for 230V operation and 250mA rating for 115V operation.

3.3.2 Connectors

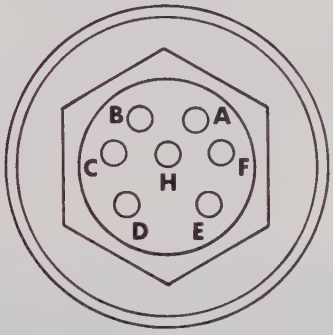
FIG 3.8 AMPHENOL CONNECTORS – PIN LAYOUT VIEWED FROM REAR OF INSTRUMENT



5-PIN CONNECTOR-EXT REF I/P



5-PIN SOCKET-ANALOGUE OUTPUT



7-PIN CONNECTOR - REAR I/P

FIG 3.9 M CONNECTORS – PIN LAYOUT

3.3.2.1 **Rear Input (Option)**

A 7-pin connector wired in parallel with the input terminals on the front panel, which accepts input signals as defined for the front panel terminals. Refer to Section 3.2.6 (for pin layout see Fig 3.9). For pin designation see following table, Fig 3.10.

NOTE: CARE SHOULD BE TAKEN TO ENSURE THAT INPUTS ARE ONLY APPLIED EITHER TO THE FRONT PANEL TERMINALS OR TO THE REAR INPUT CONNECTOR'

It should be noted also that any voltage applied to the rear input will be present at the front panel terminals which may therefore be at a dangerous potential.

FIG 3.10 Rear Input – Pin designations

Pin No.	Signal
A	Ω GUARD
B	Not used
C	I+
D	Input Hi
E	Input Lo
F	I–
H	GUARD

3.3.2.2. BCD Output – J5 (Option)

A 50-way AMPHENOL 'MICRO RIBBON' connector carrying TTL logic level signals as designated in the following table, Fig. 3.11 (for pin layout see Fig. 3.8). Refer to Section 5.5.2 for details of use.

FIG 3.11 BCD Output (J5) – Pin designations

Pin No.	Function	Description
1	2×10^{-4}	BCD O/P No. (assuming 1V range)
2	4×10^{-4}	" " "
3	8×10^{-4}	" " "
4	1×10^{-4}	" " "
5	2×10^{-3}	" " "
6	4×10^{-3}	" " "
7	8×10^{-3}	" " "
8	1×10^{-3}	" " "
9	2×10^{-2}	" " "
10	4×10^{-2}	" " "
11	8×10^{-2}	" " "
12	1×10^{-2}	" " "
13	2×10^{-1}	" " "
14	4×10^{-1}	" " "
15	8×10^{-1}	" " "
16	1×10^{-1}	" " "
17	Overload	Indicates signal > 19999(9)
18	1×10^{0}	Overrange, most significant digit
19	2×10^{-5}	BCD O/P No. ⎫
20	4×10^{-5}	" ⎬ 1051 only
21	8×10^{-5}	" ⎪
22	1×10^{-5}	" ⎭
23	$\overline{\text{SUPERFAST}}$	0 enables SF1 option - 1041 only
24	Not used	
25	$\overline{\text{Ext Ref}}$	0 indicates ext ref (option)
26	$\overline{\text{Minus Polarity}}$	0 indicates negative reading
27	$\overline{\text{Plus Polarity}}$	0 indicates positive reading
28	$\overline{\text{OHMS}}$	0 indicates resistance measurement
29	$\overline{\text{DC}}$	0 indicates DC measurement
30	$\overline{\text{AC}}$	0 indicates AC measurement
31	$\overline{\text{FILTER}}$	0 indicates filter selected 1 indicates normal
32	$\overline{\text{mV}}$	0 indicates mV or Ω, 1 indicates volts or kΩ
33	$\overline{\text{AUTO}}$	0 indicates autorange, 1 indicates normal
34	RANGE A	⎫
35	RANGE B	⎬ Decimal Point Coding (Range) See Fig 3.12
36	RANGE C	⎭
37	$\overline{\text{RANGE D}}$	1041 Options BO1 and BO2 only
38	$\overline{\text{FP control}}$	0 input inhibits front panel control buttons
39	Dig common	0 state reference (max fan-in 1 TTL load) (max fan-out 2 TTL loads)
40	$\overline{\text{HOLD}}$	External control of HOLD control
41	$\overline{\text{COMMAND}}$	External control of MANUAL control
42	$\overline{\text{PRINT INHIBIT}}$	External control of PRINT INHIBIT control
43	$\overline{\text{SIG INTEGRATE}}$	1 indicates DVM sampling I/P signal
44	$\overline{\text{DELAY}}$	External addition of filter delay after a command
45	$\overline{\text{PRINT COMMAND}}$	↓ indicates sample completed and data available.
46	Dig common	⎫
47	Dig common	⎬ Options BO1a, BO2 and BO2a only
48	Dig common	⎪
49	Dig common	⎭
50	Not used	

FIG 3.12 1041/1051 Range Coding

1051 Range Coding/1041 Range Coding for Options BO1a and BO2a.

Range	Pin 34 (A)	Pin 35 (B)	Pin 36 (C)
	Pin 8	Pin 9	Pin 10
10mV	1	0	0
100mV/Ω	0	1	0
1V/kΩ	1	1	0
10V/kΩ	0	0	1
100V/kΩ	1	0	1
1000V/kΩ	0	1	1
10000kΩ	1	1	1

– BCD Output

– Remote programming [1041 and 1051]

1041 Range Coding for Options BO1 and BO2.

Range	Pin 34 (A)	Pin 35 (B)	Pin 36 (C)	Pin 37 (D)
10mV/Ω	1	0	1	1
100mV/Ω	1	1	0	1
1V/kΩ	0	1	1	1
10V/kΩ	1	0	1	1
100V/kΩ	1	1	0	1
1000V/kΩ	1	1	1	0
10000kΩ	1	1	1	1

3.3.2.3 **Remote Programming (Option)**

A 14 way AMPHENOL 'BLUE RIBBON' connector accepting external signals to control programming of ranges and functions as designated in following table, Fig 3.13 (for pin layout see Fig 3.8).

With no connection the lines should float to a '1' state. Refer to Section 5.5.1 for details of use.

FIG 3.13 Remote Programming - Pin designations

Pin No.	Function	Description
1	Function select	1 selects filter, 0 selects normal
2	Programme common	Digital ground
3	Function select	$\overline{AC}$, 0 selects AC
4		
5	Function select	$\overline{\Omega}$, 0 selects Ω
6		
7	Ext Ref select	$\overline{Ratio}$, 0 selects external reference
8	Range select	]
9	Range Select	] See Table 3.12 (1051 Range Coding)
10	Range select	]
11	Range select	AUTO, 1 selects auto-ranging
12	REMOTE	0 indicates or selects remote operation of range and function.
13	REMOTE FUNCTION	0 selects remote operation of function (Option PO2 only).
14		

FIG 3.14 Function Select Coding

Function	Pin 3	Pin 5
DC	1	1
AC	0	1
Ω	1	0

3.3.2.4 Analog Output (Option)

A 5-pin connector providing a 1V full-range output for any nominal full-range input, with overrange capability to 2V. It is not isolated from the input terminals but is fused in both Hi and Lo lines with a fast action 10mA fuse. Pin designations are shown below and the pin layout is shown in Fig. 3.9.

Pin	Signal
A	Output Hi
B	Output Lo

The output impedance is in the order of a few ohms and no more than 5mA should be demanded.

3.3.2.5 External Reference – Ratio (Option)

A 5-pin connector accepts the signal to be used as an external reference.

Two ratio options are available and the pin designations depend on which is fitted and are shown in Fig 3.15. (For pin layout see Fig 3.9. See Section 5.6 for details of use).

Although on the 1041 the reference input can only be positive it can normally perform ratio measurements with negative reference signals because it is floating from the main signal terminals and can thus be connected in reverse. For the 1051 the reference input may be of either polarity as internal circuitry senses the polarity of the signal and the reference and enables 4 quadrant ratio measurements.

FIG 3.15 External reference – Pin designations

Pin	Designation for 1V option (R02-1041, R03-1051)	Designation for 10V/100V option (R05-1041, R06-1051).
A	Not used	Reference Input Hi (10V)
B	Not used	Reference Input Lo (10V)
D	Reference Input Lo	Reference Input Lo (100V)
E	Reference Input Hi	Reference Input Hi (100V)
H	Input Signal Lo	Input Signal Lo

3.3.3 Rear Panel Controls

REFERENCE INT/EXT (Option) – A slide switch enabling selection of internal or external reference. Selection of Ext Ref is also available via the remote programming option if this is fitted.

SECTION 4

SPECIFICATION AND SPECIFICATION VERIFICATION

4.1 SPECIFICATIONS

4.1.1 General

Power Supply	205 – 255 or 105 – 127 volts, 48 – 440Hz. Specify line frequency and voltage when ordering. Consumption is approximately 12 VA.
Operating Temperature	0^{o}C to 50^{o}C.
Storage Temperature	-25^{o}C to $+70^{o}$C.
Dimensions	H = 90mm (3.5"), W = 440mm (17.25"), D = 343mm (13.5").
Weight	5.5kg (12 lbs).
Rack Mounting	"Ears" mounted on side of instrument.
Specification Validity	For 6 months over 18 – 28^{o}C or as described.

4.1.2 1041 only

4.1.2.1 DC Voltage measurement

Ranges	10.000 mV, 100.00 mV, 1.0000 V, 10.000 V, 100.00 V, 1000.0 V Automatic.
Overrange	100% i.e. 19999 full scale (FS) on all ranges except 1000.0 V
Accuracy	After mV offset adjustment, all ranges. $\pm$ 0.01% reading $\pm$ 0.005% FS $\pm$ 1 microvolt. N.B. Use of SF1 option adds 0.05% to full scale accuracy.
Temperature Coefficient	$\pm$ 1/10 (of above accuracy rating)/^{o}C $\pm$ 0.2 microvolts/^{o}C.
Stability	After six months use better than above accuracy rating per year plus microvolt offset of typically less than 2 microvolts per month.
Common Mode Rejection (1 kΩ Source Unbalance)	DC > 140 dB AC > 80 dB + SERIES MODE up to 174 dB (1 Hz to 60Hz).

Series Mode Rejection

FILTER OUT	> 20 dB @ 50 Hz increasing at 30 dB per octave + NOTCH REJECTION
FILTER IN	> 57 dB @ 50 Hz increasing at 18 dB per octave + NOTCH REJECTION
NOTCH REJECTION	> 50 dB @ Line Frequency $\pm$ 0.15% 36 dB @ Line Frequency $\pm$ 1%
FILTER OUT – (OPTION F01)	NOTCH REJECTION alone.

Settling Time (to 0.01%)

FILTER OUT	78 milliseconds)	ADD 30 milliseconds
FILTER OUT (F01)	5 milliseconds)	if changing into or out
FILTER IN	350 milliseconds)	of 100 V, 1 kV ranges.

Read Rate

Normal internally triggered read rate ~ 2.5 readings/sec.

Maximum externally triggered read rates:

FILTER OUT	10 readings/sec.
FILTER OUT (F01)	20 readings/sec.
FILTER OUT (SF1)	150 readings/sec. (at full range), 120 readings/sec (at full scale)
FILTER IN	2.5 readings/sec.

Maximum Input Voltage (Without damage)	Signal Hi to Signal Lo	1000 V r.m.s. (Any range).
	Signal Lo to Guard	250 V peak
	Guard to Earth (Case)	500 V peak
	Any Terminal to any other in "ohms"	250 V DC or r.m.s.

NOTE: The small slide switches near the terminals connect OHMS GUARD [= Lo in voltage measurement] to GUARD or I+ to Hi and I– to Lo. Therefore if a voltage is applied across these connected (via the switches) terminals, then **SEVERE DAMAGE COULD OCCUR** necessitating the replacement of the switches and the input terminal PCB.

Input Resistance (Rin)	10 mV to 10 V ranges (up to 20 V) Rin $>$ 10.000 MΩ 100V and 1,000 V ranges Rin = 10 MΩ ± 0.1%
Input Current	$<$ 50 pA drifting at typically $<$ 3 pA/^{o}C
Auto Range	Ranges up at 200% of Nominal Range Ranges down at 10% of Nominal Range Range Speed (Typical):–
	FILTER OUT UP 160 milliseconds per Range
	FILTER OUT DOWN 120 milliseconds per Range
	FILTER IN UP 550 milliseconds per Range
	FILTER IN DOWN 500 milliseconds per Range

4.1.2.2 **AC Voltage Measurement**

Option 11

Ranges	1.0000 Volts, 10.000 Volts, 100.00 Volts, 1000.0 Volts, + Auto.
Overrange	100% i.e. 19999 FS except 1000V.
Accuracy	6 months duration 18–28^{o}C $\leqslant$ 2 x 10^{7}VHz [Signal $>$ 0.02% FS]
	* 40Hz – 5 kHz ± 0.1% reading ± 0.02% FS
	5 kHz – 20 kHz ± 0.2% reading ± 0.03% FS
	20 kHz – 100 kHz ± 0.3% reading ± 0.1% FS
	N.B. Use of SF1 option adds 0.05% to full scale accuracy.

Option 01

Ranges	10.000 mV, 100.00 mV, 1.0000 Volts, 10.000 Volts, 100.00 Volts. 10000.0 Volts + Auto.
Overrange	100% i.e. 19999 FS except 1000 Volts.
Accuracy	6 months duration 18–28^{o}C $\leqslant$ 2 x 10^{7}VHz [Signal $>$ 300μV, $>$ 0.02% FS]
	100 mV – 1000 Volt ranges:–
	* 40 Hz – 5 kHz ± 0.03% reading ± 0.01% FS
	5 kHz – 20 kHz ± 0.06% reading ± 0.02% FS
	20 kHz – 100 kHz ± 0.1% reading ± 0.05% FS
	add 1 ppm per volt above 300 Volts –Bandwidth approximately 5MHz.
	10 mV range [signal $>$ 300μV]
	* 40 Hz – 5 kHz ± 0.1% reading ± 0.05% FS
	5 kHz – 20 kHz ± 0.2% reading ± 0.05% FS
	Bandwidth approximately 500 kHz.
	N.B. Use of SF1 option adds 0.05% to full scale accuracy.

Both AC Converters

Where * noted above read 250 Hz instead of 40 Hz if Filter is Out [360 Hz if Option F01 is fitted].

Temperature Coefficient	$<$ 1/10 [above accuracy rating]/^{o}C
Common Mode Rejection	1 kΩ unbalance in Hi $>$ 120 dB @ DC – 60 Hz.
	1 kΩ unbalance in Lo $>$ 80 dB @ DC – 60 Hz.
Settling Time	(To 0.1% of final value attacking)
	FILTER OUT $<$ 80 msec.
	FILTER IN $<$ 350 msec.

Settling Time	(To 0.1% of range, decaying) **FILTER OUT** $<$ 150 msec. **FILTER IN** $<$ 500 msec.
Settling Time	(From severe overload) Up to Double the above times.
Settling Time	(From DC Bias Input) Time Constant 2.2 Secs.
Maximum Input Voltage	1500V peak on any range (Filter must be selected above 500V r.m.s.). $\leqslant 2 \times 10^7$ VHz. Measures AC component with up to 1000V DC bias on any range.
Conversion Type	True r.m.s. (AC coupled).
Input Impedance	1 MΩ shunted by 75 pF (150 pF with rear input).

4.1.2.3 Resistance Measurement Option 02

Ranges	10.000 Ohms, 100.00 Ohms, 1.0000 kΩ, 10,000 kΩ, 100.00 kΩ. 1000.0 kΩ, 10.000 kΩ + Auto.
Overrange	100% on all ranges.
Accuracy	6 months duration 18 – 28°C. 10 Ohms to 100 kΩ ± 0.01% reading ± 0.005% FS. 1 Megohm ± 0.02% reading ± 0.005% FS. 10 Megohm ± 0.1% reading ± 0.005% FS. N.B. Use of SF1 option adds 0.05% to full scale accuracy.
Temperature Coefficient	1/10 [above accuracy rating]/°C.
Type	True 4-wire with active guard (can be switched to 2-wire on front panel). Ratio measurement technique not dependent on internal reference voltage.

Current Through Unknown

10Ω and 100Ω ranges	10.000 milliamps
1kΩ	1.0000 milliamps
10kΩ	100.00 microamps
100kΩ	10.000 microamps
1 MΩ	1.0000 microamps
10 MΩ	100.0 nanoamps

Lead Resistance: Up to 100Ω may be tolerated in any or all the leads on any range without degrading the accuracy. Resistances up to 100 kΩ may be tolerated on the higher ranges provided that the lead resistance does not drop more than 1 Volt across it due to the measurement current in the above table.

Ohms Guard

Drive Capability	I+ or Lo to OHMS GUARD 250 Ohms min.
Guarding Capability	Down to 20% of range or limited by drive capability [i.e. minimum resistance between OHMS GUARD and SIGNAL Lo] for less than 0.01% accuracy degradation. Lower percentage of range will degrade accuracy as:–

$$\frac{\text{FULL RANGE}}{\text{GUARDED RESISTANCE}} \times 0.002\% \text{ reading.}$$

Response Times: Depends on external capacitance and guarding and shielding techniques used. Generally up to 100 kΩ response is as DC. Higher resistances may take longer to settle. OHMS GUARD may be used to guard out stray capacitance.

4.1.2.4 External Reference (Ratio)

Capability	DC/DC, AC/DC, OHMS/DC.
Type	4-wire positive reference

Temperature Coefficient	1/10th accuracy rating/^{O}C.
Common Mode Rejection	> 60 dB DC – 60 Hz.
Series Mode Rejection	36 dB @ 50 Hz increasing at 40 dB per decade.
Response Time	1 sec. to .01% final value.

Option R02

Ranges	External Reference Input + 0.2 V to + 1.2 V. Signal Input As function and range.
Accuracy	$\pm$ X% reading $\pm$ Y $\frac{1}{\text{ref}}$ % FS.

X = appropriate % reading spec. for signal input range and function selected.

Y = appropriate % full scale spec. for signal input range and function selected

e.g. for DC signal input accuracy is:–

$$\pm 0.01\% \text{ reading} \pm 0.005\frac{1}{\text{ref}}\% \text{ FS.}$$

Input Resistance	1000 MΩ differential. 100 MΩ ref. Hi to Signal Lo.
Common Mode Voltage (w.r.t. Signal Lo)	$\pm$ 10 V max.
Maximum Reference Input (without damage)	250 V DC or r.m.s.

Option R05

Ranges	External Reference Input: + 2 V to + 12 V (10 V range) + 20V to + 120 V (100 V range) Signal Input: As function and range.
Accuracy	$\pm$ X reading $\pm \frac{10V}{\text{ref}}$ % FS (10 V range) $\pm$ X reading $\pm$ Y $\frac{100V}{\text{ref}}$ % FS (100 V range) Where X and Y are as Option R02.
Input Resistance	1 MΩ $\pm$ .5% (10 V range) 10 M Ω $\pm$ .5% (100 V range)
Common Mode Voltage (w.r.t. Signal Lo)	$\pm$ 100 V max. (10 V range) $\pm$ 500 V max. (100 V range)
Maximum Reference Input (without damage)	$\pm$ 500 V DC or peak

4.1.2.5 Analogue Output

Range	0 $\pm$ 2 Volts, 1 Volt per nominal Full Range.
Output Resistance	< 10 Ohms.
Output Current	Up to 5 milliamps.
Protection	Fuse protected against accidental overload in both Output Hi and Output Lo leads.

4.1.2.6 BCD Output

Option B01 gives reading, range and function 1.2.4.8. +ve true TTL compatible code. External Hold and Read Command facilities are provided together with sig integrate and print command output flags. FAN OUT : 2 TTL LOADS, FAN IN

Option B02 is as B01 but with the added facility of turning all the outputs into a high impedance condition (i.e. "OFF") and disabling all inputs.

Both options are electrically isolated from the signal input terminals.

4.1.2.7 Programming

Option P01 gives the capability of fully programming the instrument with TTL signals via a rear panel mounted connector. All ranges and functions may be programmed and all front panel controls disabled with the exception of the two terminal slide switches. Fan in 1 TTL load maximum.

4.1.3. 1051 only

4.1.3.1 DC Voltage Measurement

Ranges	100.000 mV, 1.00000 V, 10.0000V, 100.000 V, 1000.00 V, + Auto 10.0000 mV (Manual only).
Overrange	100% i.e. 199999 full scale (FS) on all ranges except 1000.00 V.
Accuracy (6 months)	After mV offset adjustment, all ranges. ± 0.005% reading ± 0.0005% FS ± 1 microvolt.
Temperature Coefficient	± 1/10 [of above accuracy rating] /^{o}C ± 0.2 microvolts/^{o}C.
Stability	After six months use better than 50 ppm per year.
Short Term Accuracy	As above but .002% reading 24 hrs 22 – 24^{o}C .004% reading 90 days 18 – 28^{o}C
Common Mode Rejection (1 kΩ Source Unbalance)	DC > 140 dB AC > 80 dB + SERIES MODE up to 180 dB
Series Mode Rejection	**FILTER OUT** (100mV – 1KV): > 70dB, > 60dB, > 46dB — notch at, and multiples of line frequency, with a line frequency slew rate: < .06% / minute, < .25% / minute, < . 1% / minute **FILTER IN** (100 mV – 1 kV): > Above notch + 36 dB at 50 Hz increasing at 40 dB per decade. 10 mV Range: > Above + 46 dB at 50 Hz increasing at 20 dB per decade.
Settling Time (to .001%)	**FILTER OUT** < 5 milliseconds **FILTER IN** < 350 milliseconds 10 mV Range only approx. 10 seconds
Read Rate	Normal internally triggered read rate ~ 2.5 readings/sec. Maximum externally triggered read rate:– **FILTER OUT** 20 readings/sec. **FILTER IN** 2.5 readings/sec.
Maximum Input Voltage (without damage)	Signal Hi to Signal Lo: 1000 V r.m.s. (Any Range) Signal Lo to Guard: 250 V peak Guard to Earth (Case): 500 V peak Any Terminal to any other in "ohms": 250 V DC or r.m.s.

NOTE: The small slide switches near the terminals connect OHMS GUARD [= Lo in voltage measurement] to GUARD or I+ to Hi and I– to Lo. Therefore if a voltage is applied across these connected (via the switches) terminals, then **SEVERE DAMAGE COULD OCCUR** necessitating the replacement of the switches and the input terminal PCB.

Input Resistance (Rin)	10 mV to 10 V ranges (up to 20V) Rin > 10,000 MΩ 100 V and 1,000 V ranges Rin = 10 MΩ ± 0.1%
Input Current	< 50 pA drifting at typically 3 pA/^{o}C

Auto Range	Ranges up at 200% of Nominal Range Ranges down at 10% of Nominal Range Range Speed (Typical):– **FILTER OUT UP** 70 milliseconds per Range **FILTER OUT DOWN** 30 milliseconds per Range **FILTER IN UP** 460 milliseconds per Range **FILTER IN DOWN** 420 milliseconds per Range

4.1.3.2 **AC Voltage Measurement**

Option 11

Ranges	1.00000 Volts, 10.0000 Volts, 100.000 Volts, 1000.00 Volts, + Auto
Overrange	100%, i.e. 199999 FS except 1000 V.
Accuracy	6 months duration 18–28°C $\leqslant 2 \times 10^7$ VHz [Signal $>$ 0.02% FS] *40 Hz – 5kHz ± 0.1% reading ± 0.02% FS 5 kHz – 20 kHz ± 0.2% reading ± 0.03% FS 20 kHz – 100 kHz ± 0.3% reading ± 0.1% FS

Option 01

Ranges	100.000 mV, 1.00000 Volts, 10.0000 Volts, 100.000 Volts, 1000.00 Volts + Auto
Overrange	100% i.e. 199999 FS except 1000 Volts.
Accuracy	6 months duration 18–28°C $\leqslant 2 \times 10^7$ VHz [Signal $>$ 300μV, $>$ 0.02% FS] 100 mV – 1000 Volt ranges:– *40 Hz – 5 kHz ± 0.03% reading ± 0.01% FS 5 kHz – 20 kHz ± 0.06% reading ± 0.02% FS 20 kHz – 100 kHz ± 0.1% reading ± 0.05% FS add 1 ppm per volt above 300 Volts – Bandwidth approximately 5 MHz.

Both AC Converters

Where * noted above read 360 Hz instead of 40 Hz if Filter is Out.

Temperature Coefficient	$<$ 1/10 [above accuracy rating]/°C.
Common Mode Rejection	1 kΩ unbalance in Hi $>$ 120 dB @ DC – 60 Hz 1 kΩ unbalance in Lo $>$ 80 dB @ DC – 60 Hz
Settling Time	(To 0.1% of final value attacking) **FILTER OUT** $<$ 80 msec. **FILTER IN** $<$ 350 msec.
Settling Time	(To 0.1% of range, decaying) **FILTER OUT** $<$ 150 msec. **FILTER IN** $<$ 500 msec.
Settling Time	(From severe overload) Up to Double the above times.
Settling Time	(From DC Bias Input) Time Constant 2.2 Secs
Maximum Input Voltage	1500V peak on any range (Filter must be selected above 500V r.m.s.). $\leqslant 2 \times 10^7$ VHz. Measures AC component with up to 1000V DC bias on any range.
Conversion Type	True r.m.s. (AC coupled)
Input Impedance	1 MΩ shunted by 75 pF (150 pF with rear input).

4.1.3.3 Resistance Measurement Option 03

Ranges	100.000 Ohms, 1.00000 kΩ, 10.0000 kΩ, 100.000 kΩ, 1000.00 kΩ, 10.0000 MΩ, + Auto.
Overrange	100% on all ranges.
Accuracy	6 months duration 18 – 28°C 100 Ohms to 100 kΩ ± 0.005% reading ± 0.0005% FS 1 Megohm ± 0.02% reading ± 0.001% FS 10 Megohm ± 0.1% reading ± 0.001% FS
Temperature Coefficient	1/10 [above accuracy rating]/°C.
Type	True 4-wire with active guard (can be switched to 2-wire on front panel). Ratio measurement technique not dependent on internal reference voltage.
Short Term Accuracy	100 Ohms to 100 kΩ as above but .002% reading 24 hrs 22 – 24°C. .004% reading 90 days 18 – 28°C.
Current Through Unknown	100Ω 10.000 milliamps 1 kΩ 1.0000 milliamps 10 kΩ 100.00 microamps 100 kΩ 10.000 microamps 1 MΩ 1.0000 microamps 10 MΩ 100.0 nanoamps
Lead Resistance	Up to 100Ω may be tolerated in any or all the leads on any range without degrading the accuracy. Resistances up to 100 kΩ may be tolerated on the higher ranges provided that the lead resistance does not drop more than 1 Volt across it due to the measurement current in the above table.

Ohms Guard

Drive Capability	I+ or Lo to OHMS GUARD 250 Ohms min.
Guarding Capability	Down to 20% of range or limited by drive capability [i.e. minimum resistance between OHMS GUARD and SIGNAL Lo] for less than 0.01% accuracy degradation. Lower percentage of range will degrade accuracy as:– $\frac{\text{FULL RANGE}}{\text{GUARDED RESISTANCE}}$ x 0.002% reading
Response Times	Depends on external capacitance and guarding and shielding techniques used. Generally up to 100 kΩ response is as DC. Higher resistances may take longer to settle. OHMS GUARD may be used to guard out stray capacitance.

4.1.3.4 External Reference (Ratio)

Capability	DC/DC, AC/DC, OHMS/DC.
Type	4-wire, 4 quadrant
Temperature Coefficient	1/10th accuracy rating/°C.
Common Mode Rejection	> 60 dB DC – 60 Hz.
Series Mode Rejection	36 dB @ 50 Hz increasing at 40 dB per decade.
Response Time	1 sec to .01% final value.

Option R03

Ranges	External Reference Input ± 0.3V to ± 2 V Signal Input As function and range

Accuracy (6 months)	$\pm$ X% signal input $\pm$ (.0005 + Y) $\frac{2}{\text{ref. input}}$ % FS
	Where X = appropriate % reading spec. for Signal input range and function selected.
	Y = appropriate % full scale spec. for signal input range and function selected
	e.g. for DC Signal input accuracy is:–
	$\pm$0.005% signal input $\pm$ 0.001 $\frac{2}{\text{ref.}}$ % FS
Input Resistance	1000 MΩ differential 100 MΩ ref. Hi to Signal Lo
Common Mode Voltage (w.r.t. Signal Lo)	$\pm$ 10 V Max

Option R06

Ranges	External Reference Input $\pm$ 3 V to $\pm$ 20 V (10 V range) $\pm$ 30 V to $\pm$ 200 V (100 V range) Signal Input As function and range.
Accuracy	$\pm$ X% reading $\pm$ Y.$\frac{40}{\text{ref}}$% FS (10 V range)
	$\pm$ X% reading $\pm$ Y.$\frac{400}{\text{ref}}$ % FS (100 V range)
	Where X and Y are as Option R03.
Input Resistance	1 MΩ $\pm$ .1% (10 V range) 10 MΩ $\pm$ .1% (100 V range)
Common Mode Voltage (w.r.t. Signal Lo)	$\pm$ 100 V max. (10 V range) $\pm$ 500 V max. (100 V range)
Maximum Reference Input (without damage)	$\pm$ 500 V DC or peak

4.1.3.5 Analogue Output

Accuracy	As normal specifications $\pm$ .01% FS
Range	0 $\pm$ 2 Volts. 1 Volt per nominal Full Range
Output Resistance	$<$ 10 Ohms.
Output Current	Up to 5 milliamps.
Protection	Fuse protected against accidental overload in both Output Hi and Output Lo leads.

4.1.3.6 BCD Output

Option B04 gives reading, range and function 1.2.4.8. +ve true TTL compatible code. External Hold and Read Command facilities are provided together with signal integrate and print command output flags. FAN OUT : 2 TTL LOADS. FAN IN : 1.
Provided as standard is the facility of turning all the outputs into a high impedance condition (i.e. "OFF") and disabling all inputs.
Option is electrically isolated from the signal input terminals and referred to power ground via a 100 kΩ resistor.

4.1.3.7 Programming

Option P01 gives the capability of fully programming the instrument with TTL or CMOS signals via a rear panel mounted connector. All ranges and functions may be programmed and all front panel controls disabled with the exception of the two terminal slide switches. Fan in 1 TTL load maximum.

4.2 SPECIFICATION VERIFICATION

4.2.1 Description

The following section is a procedure to check that the instrument is working within its specified accuracy where the intention is not to re-calibrate internally. It is thus useful for incoming inspection or routine calibration checks.

It is recommended that due to the wide measurement capability of the instrument, only those aspects of the specification relevant to normal use be verified. This saves considerably in both time and calibration equipment, especially where the 1μV resolution or h.f AC performance are not required. For general purpose measurements, the whole procedure should be followed to verify the entire specification.

NOTE: Ideally the specification verification procedure should be carried out with the instrument at 23°C but the specification is valid from 18°C to 28°C. Measurements taken outside this temperature range should take into account the specified temperature coefficients in order to verify the specification.

4.2.2 1041 Equipment requirements

(i) for DC checks – a DC source is required of accuracy at least three times better than the accuracy being verified, from 10mV to 1000V.

Examples: Julie Research DVS 106
Optimation AC126P/A226 (For AC & DC)

(ii) for AC checks – Optimation AC125/PA225
Hewlett Packard 745/746
Optimation AC126/PA226 (AC & DC)

(iii) for OHMS checks – a set of standard resistors covering 10Ω to 10MΩ. The 10Ω and 100Ω resistors should be 4-wire types.

(iv) for external reference checks – a stable DC source of approximately
1 V and .2V for RO2
10V and 100V] for RO5
2V and 20V]

4.2.3 1041 Procedure

Turn on the instrument to be checked and allow a minimum of 2 hours to warm up (see Section 2.3, SWITCH-ON).

4.2.3.1 DC Performance

(i) Switch instrument to 1 volt range. Flick the Local/Remote Guard switch to LOCAL.

(ii) Connect Hi to Lo with a short link.
Check the instrument reads .0000 ± .0001V.

(iii) Apply +1.0000 volts check reading is
+1.0000 ± .0002V

(iv) Apply –1.0000 volts check reading is
–1.0000 ± .0002V.

If (ii) to (iv) are passed this indicates that most of the instrument is working correctly. If it is failed by more than 0.3% then it is likely that there is a fault rather than a calibration error

(v) Select 10V range

Apply +10.000V check reading is
+10.000 ± .002V

(vi) Apply –10.000V check reading is
–10.000 ± .002V

(vii) Select 100V range

Apply +100.00V check reading is
+100.00 ± .02V

(viii) Apply −100.00V check reading is
−100.00 ± .02V

(ix) Select 1kV range

Apply +1000.0V check reading is
+1000.0 ± 0.2V

(x) Apply −1000.0V check reading is
−1000.0 ± 0.2V

(xi) Select 10mV range. Turn DC source down to zero. Allow several minutes for thermal e.m.f.'s to disappear or stabilize.

Adjust mV offset for display of ± 0.000mV

Apply +10.000mV, check reading is
+10.000 ± 0.003mV

(xii) Apply −10.000mV, check reading is
−10.000 ± 0.003mV

(if changing polarity involves reversing leads, check zero again as thermal e.m.f.'s may have changed. If possible reverse polarity at a higher voltage level so as not to reverse thermals).

(xiii) Select 100mV range

Apply +100.00mV, check reading is
+100.00 ± 0.02mV

(xiv) Apply −100.00mV, check reading is
−100.00 ± 0.02mV

This concludes checking of accuracy.

(xv) For linearity check, select 1 volt range.

Apply +0.1000V, check reading is
+0.1000V ± 0.001V

(xvi) Apply +0.5000V, check reading is
+0.5000 ± 0.0001/2V

(xvii) Apply +1.000V, check reading is
+1.000 ± .0002V

(xviii) Apply +1.9000V, check reading is
+1.9000 ± .0003V

DC Verification is now complete.

4.2.3.2 **Procedure AC Performance**

(i) Carry out 4.2.3.1 (i) and switch to FILTER

(ii) Connect Hi to Lo with a short link.
Check instrument reads .0003 maximum.

(iii) The check readings in the following list will have two limits. The first is for the model 01, the second of wider limits the model 11.

(iv) Apply 1.0000 volts at 5 kHz, 20 kHz, 100 kHz in turn. Check readings are respectively:

1.0000 ± .0005 (.0014) V
1.0000 ± .0010 (.0030) V
1.0000 ± .0020 (.0050) V

If this test is failed by more than about .3% at 5 kHz or 2% at 100 kHz there is probably a fault rather than a calibration error.

(v) Repeat (iv) for the 10V range with 10V input. Check readings are:

10.000 ± .005 (.014) V
10.000 ± .010 (.030) V
10.000 ± .020 (.050) V

(vi) Repeat (iv) for the 100V range with 100V input. Check readings are:

100.00 ± .05 (.14) V
100.00 ± .10 (.30) V
100.00 ± .20 (.50) V

(vii) Apply 1000 volts on the 1000V range at 5kHz and 10kHz.

NOTE: Take care that $<$ 500 volts peak range is applied between Lo, Guard, and Earth. Also ensure that the maximum gain bandwidth product is not exceeded, e.g. 20kHz at 1000 volts.

Check the readings are respectively:

1000.0 ± 1.2 (2.1) V
1000.0 ± 1.7 (3.7) V

At 300 V check readings are:

300.0 ± .3 (.7) V
300.0 ± .6 (1.6) V

(viii) The remaining steps do not apply to the type 11 converter.

(ix) Repeat (iv) for the 10mV range with 10mV applied. 100 kHz is not applicable to this range. Check readings are:

10.000 ± .020 mV
10.000 ± .030 mV

(x) Repeat (iv) for the 100 mV range with 100 mV applied. Check readings are:

100.00 ± .05 mV
100.00 ± .10 mV
100.00 ± .20 mV

AC verification is now complete.

4.2.3.3 Procedure – Ohms Performance

(i) Carry out step 4.2.3.1. (i).

(ii) Select 10Ω, 4-wire: connect the 10Ω resistor in a 4 terminal measurement.

Check instrument reading is:

10.000 ± .003Ω

(iii) Select 100Ω, 4-wire, connect the 100Ω resistor in a 4 terminal measurement. Check reading is:

100.00 ± .02Ω

(iv) Select 1kΩ , 4-wire. Connect the 1kΩ resistor for 4-wire. Check reading is:

1.000 ± .0002 kΩ

(v) Select 10 kΩ 2-wire. Connect the 10kΩ resistor to Hi and Lo. Check reading is

10.000 ± .002 kΩ

(vi) Select 100 kΩ, 2-wire. Connect the 100 kΩ resistor to Hi and Lo. Check reading is:

100.00 ± .02 kΩ

(vii) Select 1 MΩ, 2-wire. Connect the 1 MΩ resistor to Hi and Lo. Check reading is:

1000.0 ± .3 kΩ

(viii) Select 10MΩ, 2-wire. Connect the 10MΩ resistor to Hi and Lo. Check reading is:

10000 ± 11 kΩ

If long unscreened leads are used on the last two measurements, the use of FILTER will reduce the digit jitter, due to 50 Hz pick-up.

If high value standard resistors have a guard terminal then connect this to ohms guard.

If all the checks made in Section 4.2.3.3. are made, and met, this confirms that the model 1041 is within its calibration specification for resistance.

4.2.3.4 **Procedure External Reference**

Make sure that the DC signal measurement is working correctly as in Section 4.2.3.1. Switch the rear panel slide switch to external reference.

For R02 only

(i) Connect Signal Hi to Reference Hi and Signal Lo to Reference Lo. Switch Guard to Local, and to 1V range.

Apply approximately +1V to the commoned signal and reference inputs. Check the reading is:

1.0000 ± .0002

(ii) Repeat (i) with +0.2 volts. Check reading is:

1.0000 ± .0006

If these conditions are met then the external reference option R02 is functioning correctly.

For R05 only

(iii) Connect Signal Hi to 10V reference Hi and signal Lo to 10V reference Lo. Switch guard to local and to 10V range. Apply approximately 10V to the commoned inputs. Check that the reading is:

10.000 ± .002

(iv) Repeat (iii) with 2V, check that reading is:

10.000 ± .006

(v) Connect Signal Hi to 100V reference Hi and Signal Lo to 100V reference Lo. Switch to 100V range. Apply approximately 100V to the commoned inputs. Check that the reading is:

100.00 ± .02

(vi) Repeat (v) with approximately 20V, check that reading is:

100.00 ± .06

If these conditions are met then the external reference option R05 is functioning correctly.

4.2.4 1051 Equipment requirements

(i) For DC checks – a DC source is required of accuracy at least three times better than the accuracy being verified, from 10mV to 1000V.

Examples:– Julie Research DVS 106
Fluke 332D
Precision Attenuator for low voltages

(ii) for AC checks– Optimation AC125/PA225
Hewlett Packard 745/746
Optimation AC126/PA226 (AC & DC)

(iii) For OHMS checks – a set of standard resistors covering 100Ω to 10MΩ. The 100Ω resistor should be 4-wire type.

(iv) For external reference checks – a stable DC source of approximately
2V and .3V – for R03
20V and 200V] for R06
3V and 30V]

4.2.5 1051 Procedures

Turn on the instrument to be checked and allow a minimum of 2 hours to warm up (see Section 2.3, SWITCH-ON).

4.2.5.1 Procedure – DC Performance

NOTE: The limits specified in these procedures apply only if the instrument is checked within 90 days of despatch or recalibration. When checking the instrument after this time, but before 6 months has elapsed, the limits should be adjusted according to the 6 months Accuracy Specification.

(i) Switch instrument to 1 volt range. Flick the Local/Remote Guard switch to LOCAL.

(ii) Connect Hi to Lo with a short link.
Check the instrument reads .00000 ± .00001V

(iii) Apply +1.00000 volts, check reading is:
+1.00000 ± .00005V

(iv) Apply –1.00000 volts, check reading is:
–1.00000 ± .00005V

If (ii) to (iv) are passed this indicates that most of the instrument is working correctly. If it is failed by more than 0.3% then it is likely that there is a fault rather than a calibration error.

(v) Select 10V range

Apply +10.0000 V, check reading is
+10.0000 ± .0005V

(vi) Apply –10.0000V, check reading is
–10.0000 ± .0005V

(vii) Select 100V range

Apply +100.000 V, check reading is
+100.000 ± .005V

(viii) Apply –100.000 V, check reading is
–100.000 ± .005V

(ix) Select 1kV range

Apply +1000.00 V, check reading is
+1000.00 ± .05V

(x) Apply --1000.00 V, check reading is
--1000.00 ± .05V

(xi) Select 10mV range. Turn DC source down to zero. Allow several minutes for thermal e.m.f.'s to disappear or stabilize.

Adjust mV offset for display of 0.000 mV

Apply +10.0000 mV, check reading is
+10.0000 ± .0015 mV

(xii) Apply --10.0000 mV, check reading is
--10.0000 ± .0015 mV

(If changing polarity involves reversing leads, check zero again as thermal e.m.f.'s may have changed. If possible reverse polarity at a higher voltage level so as not to reverse thermals).

(xiii) Select 100mV range. Turn DC source down to zero. Allow several minutes for thermal e.m.f.'s to disappear or stabilize.

Adjust mV offset for display of ± 0.0000 mV

Apply +100.000 mV, check reading is
+100.000 ± .006 mV

(xiv) Apply --100.000 mV, check reading is
--100.000 ± .006 mV

(If changing polarity involves reversing leads, check zero again as thermal e.m.f.'s may have changed. If possible reverse polarity at a higher voltage level so as not to reverse thermals).

This concludes checking of accuracy.

(xv) For linearity check, select 1 volt range.

Apply +0.10000 V, check reading is
+0.10000 ± .00001 V

(xvi) Apply +0.50000 V, check reading is
+0.50000 ± .00003 V

(xvii) Apply +1.00000 V, check reading is
+1.00000 ± .00005V

(xviii) Apply +1.90000 V, check reading is
+1.90000 ± .00009 V

DC verification is now complete.

4.2.5.2 **Procedure AC Performance**

(i) Carry out 4.2.5.2.(i) and switch to FILTER.

(ii) Connect Hi to Lo with a short link. Check instrument reads .00030 maximum.

(iii) The check readings in the following list will have two limits. The first is for the model 01, the second of wider limits the model 11.

(iv) Apply 1.0000 volts at 5 kHz, 20 kHz, 100 kHz in turn. Check the readings are respectively:

1.00000 ± .00050 (.00140) V
1.00000 ± .00100 (.00300) V
1.00000 ± .00200 (.00500) V

If this test is failed by more than about .3% at 5 kHz or 2% at 100 kHz there is probably a fault rather than a calibration error.

(v) Repeat (iv) for the 10V range with 10V input. Check readings are:

10.0000 ± .0050 (.0140) V
10.0000 ± .0100 (.0300) V
10.0000 ± .0200 (.0500) V

(vi) Repeat (iv) for the 100V range with 100V input. Check readings are:

100.000 ± .050 (.140) V
100.000 ± .100 (.300) V
100.000 ± .200 (.500) V

(vii) Apply 1000 volts on the 1000V range at 5kHz and 10kHz.

NOTE: Take care that $<$ 500 volts peak range is applied between Lo, Guard, and Earth. Also ensure that the maximum gain bandwidth product is not exceeded, e.g. 20kHz at 1000 volts.

Check the readings are respectively:

1000.00 ± 1.20 (2.10) V
1000.00 ± 1.70 (3.70) V

At 300V check readings are:

300.00 ± .30 (.70) V
300.00 ± .60 (1.60) V

(viii) The remaining steps do not apply to the type 11 converter.

(ix) Repeat (iv) for the 100 mV range with 100 mV applied. Check readings are:

100.000 ± .050 mV
100.000 ± .100 mV
100.000 ± .200 mV

AC verification is now complete.

4.2.5.3 **Procedure - OHMS Performance**

(i) C rry out step 4.2.5.1.(i)

(ii) Select 100Ω, 4-wire, connect the 100Ω resistor in a 4 terminal measurement. Check reading is:

100.00 ± .007Ω

(iii) Select 1kΩ, 4-wire, connect the 1kΩ resistor for 4-wire. Check reading is:

1.00000 ± .00007 kΩ

(iv) Select 10kΩ, 2-wire. Connect the 10kΩ resistor to Hi and Lo. Check reading is:

10.0000 ± .0007 kΩ

(v) Select 100kΩ, 2-wire. Connect the 100kΩ resistor to Hi and Lo. Check reading is:

100.000 ± .007 kΩ

(vi) Select 1MΩ, 2-wire. Connect the 1MΩ resistor to Hi and Lo. Check reading is:

1000.00 ± .22 kΩ

(vii) Select 10MΩ, 2-wire. Connect the 10MΩ resistor to Hi and Lo. Check reading is:

10.0000 ± .0102 MΩ

If long unscreened leads are used on the last two measurements, the use of FILTER will reduce the digit jitter, due to 50 kHz pick-up.

If high value standard resistors have a guard terminal then connect this to ohms guard.

If all checks made in Section 4.2.5.3 are made, and met, this confirms that the model 1051 is within its calibration specification for resistance.

4.2.5.4 Procedure External Reference

Make sure that the DC signal measurement is working correctly as in Section 4.2.5.1. Switch the rear panel slide switch to external reference.

(i) For RO3 only

Connect Signal Hi to Reference Hi and Signal Lo to Reference Lo. Switch Guard to Local, and to 1V range. Apply approximately +2V to the commoned signal and reference inputs. Check the reading is:

1.00000 ± .00012

(ii) Repeat (i) with +0.3 volts. Check reading is:

1.00000 ± ,00015

If these conditions are met then the external reference option R03 is functioning correctly.

(iii) For R06 only

Connect Signal Hi to 10V reference Hi and Signal Lo to 10V reference Lo. Switch Guard to Local and to 10V range. Apply approximately 20V to the commoned inputs. Check that the reading is:

10.0000 ± .0007

(iv) Repeat (iii) with 3V, check that reading is:

10.0000 ± .0018

(v) Connect Signal Hi to 100V reference Hi and Signal Lo to 100V reference Lo. Switch to 100V range. Apply approximately 200V to the commoned inputs, check that the reading is:

100.000 ± .007

(vi) Repeat (v) with approximately 30V, check that reading is:

100.000 ± .018

If these conditions are met then the external reference option R06 is functioning correctly.

SECTION 5

OPERATION AND APPLICATIONS

5.1 INTRODUCTION

This section is intended as a guide to the use of the instrument and should be read in conjunction with Section 2.3 SWITCH-ON, Section 3 CONTROLS AND CONNECTIONS with special reference to Section 3.2.6 Input Connections.

5.2 COMMON MODE AND GUARD

Common Mode Voltages are equally present on both terminals of the voltage source being measured and excessive levels, either AC or DC, can affect the measurement being made. However, sensible use of the GUARD terminal can reduce errors to a negligible level.

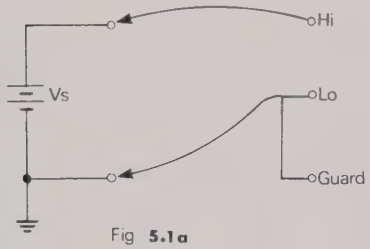


Fig **5.1a**

The disadvantage of the simple arrangement in Fig. 5.1(a) is that the connecting leads form a loop. If a stray alternating magnetic field from the mains transformer of a neighbouring instrument passes through the loop it will behave as a single turn secondary winding, and unwanted AC voltages will be induced into the measuring circuit.

The GUARD terminal should be used when the source to be measured presents an unbalanced impedance to the measuring terminals and Common Mode Voltages are present. In general, regardless how the Hi and Lo terminals are connected, the GUARD terminal should refer to the source of Common Mode Voltage as shown in Figs. 5.1 (b), (c), (d), and (e).

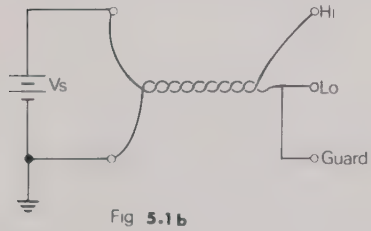


Fig **5.1b**

Fig. 5.1(b) is a better arrangement, where the twisted pair reduces the loop area and adjacent twists of the wires produce cancellation of any induced voltages.

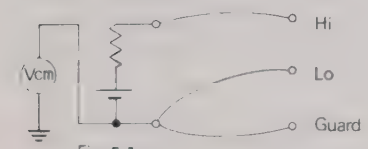


Fig **5.1c**

The simple case in Fig. 5.1(c) allows the GUARD to be connected remotely or at the terminals since in both cases it is to the source of Common Mode Voltages.

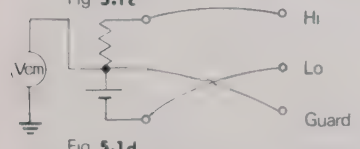


Fig **5.1d**

Fig. 5.1(d) shows a case where the Common Mode Voltage is not present on the Lo measurement terminal and should therefore be connected remotely.

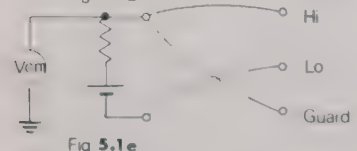


Fig **5.1e**

Fig. 5.1(e) shows an extreme situation where all the unbalance to Common Mode Voltage is in the Lo lead and GUARD must therefore be connected to Hi.

The cases above show the connections made by use of individual wires. It is recommended, however, that a screened twisted pair microphone cable be used with the GUARD terminal connected to the screen. Fig. 5.2 lists the recommended types.

FIG 5.2 Recommended Input Cables

Manufacture	Type	pF/metre	Outside diameter
Suhner	G03939	65	4.6 mm
Suhner	CB04730	195	5.3 mm
Transradio	MC 02-A	115	4.4 mm
Transradio	MC 02-D	130	3.5 mm
B.I.C.C.	9442Y	120	5.7 mm

When making a particular measurement, choose the most suitable method of connection and check that it does not involve exceeding any of the input voltages listed under Section 3.2.6.

5.3 THERMAL E.M.F.

Where very low level measurements are being made, care must be taken to minimise and balance thermal e.m.f. generated in the leads. In general, the use of steel probes, croc-clips and all metals with the exception of copper is to be avoided.

5.4. RESISTANCE MEASUREMENTS

Resistances can be most simply measured by switching the front panel slide switch to "2-wire" thus connection I+ to Hi and I– to Lo. The unknown resistor is then simply connected between Hi and Lo.

N.B. Any voltage applied to Hi and Lo with "2-wire" selected thus appears at I+ and I–.

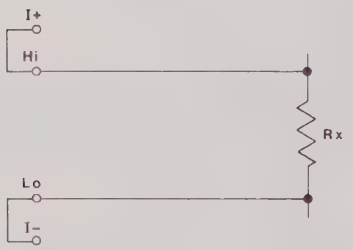


FIG 5.3a

This system measures Rx but has the snag that lead resistances are in series with Rx and thus provide a measurement error. The leads are also unscreened and pick up considerable noise particularly where Rx is high.

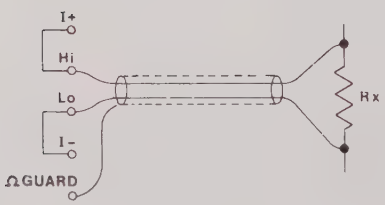


FIG 5.3b

This system overcomes the noise problem described above but still may not be suitable for the accurate measurement of very low or very high resistances particularly when the leads are long. GUARD should be switched to LOCAL.

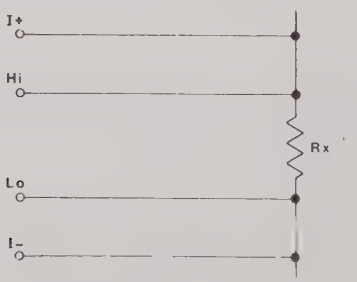


FIG 5.3c

Any resistance in the leads in this system has no effect since, if in the current leads it does not affect the current through Rx and sense leads are very high impedance and not carrying current.

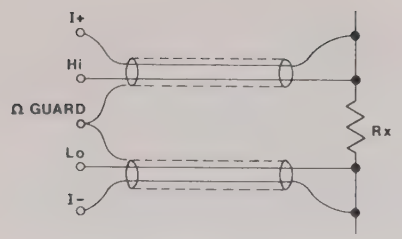


FIG 5.3d

This method combines ideal screening with the 4-wire technique. It is also suitable for high resistances with long cables since the effects of leakage and capacitance between the wires is eliminated.

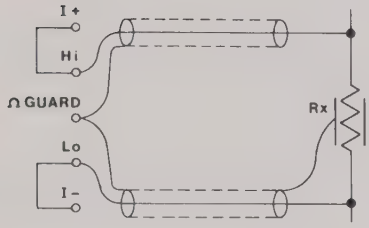


FIG 5.3e

In this case a two-wire technique is used for very high resistance measurements and the OHMS GUARD connected to a guard screen wrapped around the resistor (or the case it is mounted in). Since I+ = Hi and I– = Lo two screened cables may be used, I+ with Ω Guard Screen, I– with Guard Screen for optimum guarding.

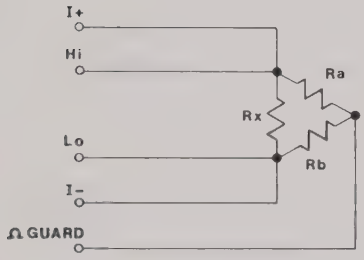


FIG 5.3f

This system shows how OHMS GUARD can be used to make "In-circuit" measurements. Provided Ra and Rb are no less than 250Ω or 20% of RANGE then the system measures Rx to full accuracy. It may of course be combined with the screening techniques above.

Additional shunt paths may also be connected to OHMS GUARD provided the parallel combination is no less than 250Ω or 20% of range.

5.5 SYSTEM OPERATION

The 1041/1051 DVM's may be used as system devices by the use of the Programming Option and the BCD output option.

5.5.1 Remote Programming (Option)

This allows all ranges and functions to be remotely controlled via the remote programming connector, detailed in Section 3.3.2.3.

All programme lines are electrically isolated from the signal input terminals.

Programme common (digital common) may be floated to a different potential from earth but it is internally referenced to earth via a 100kΩ resistor. It is therefore recommended that programme common be referred to earth in the measurement system; the signal input terminals are then able to float ± 500V peak relative to earth and digital common.

The selection of the required function is achieved by coding two lines as shown in Fig. 3.14. Filter and external reference have their own control lines. The selection of the required range is performed by coding three lines as shown in Fig 3.12 and ensuring that auto ranging is not selected as this will override any other range selection.

All the range and function lines are enabled by REMOTE from the front panel or via the programme connector as described.

With no connections the programming lines float to a '1' state and normally if REMOTE is enabled the instrument will relax to the safe condition of AUTO, DC VOLTS.

Programme logic levels are TTL compatible with a fan-in no greater than one TTL load. A '0' state should be no greater than .4 volts relative to programme common and a '1' state no less than 2.4 volts.

Programme lines are not protected against over voltage transients and therefore great care should be taken to ensure that no spikes, even of very short duration, exceed 5 volts relative to common.

5.5.2 **BCD Output Option**

This allows the control of the A-D converter and output indications of range, function and reading via the BCD output connector as detailed in Section 3.3.2.2.

In these options the outputs are isolated from the signal input terminals and referred to earth via a 100kΩ resistor.

Whilst it is recommended that the output, digital common be referred to true earth, the input terminals may be floated as high as 500V relative to true earth and digital common. All levels are TTL compatible with a fan-out of 2.

Options B02 and B04 are 3-state (or Tri-State*) versions of option B01. The difference being that a logic '0' to PRINT INHIBIT, either via the BCD connector or by depressing the front panel switch, forces all output lines to a third, inactive state which is a very high impedance OFF state.

This enables the instrument to be permanently connected to logic highways or bus-bars in a system and then, by the application of a single logic '0' to PRINT INHIBIT, be electrically disconnected when required.

The following description of signals refers to Fig 3.11. Bar notation indicates that a low level (less than 0.4V) is the active state of the line.

There are 4 output lines for each digit indicating the BCD equivalent of its value, with single lines to indicate overrange and overload. There are single lines which when at logic '0' indicate polarity, function, external reference selected, filter selected, mV range and auto ranging selected. Indication of the selected range is given as the coding on 4 lines as shown in Fig 3.12.

The A-D Converter control lines are as follows:–

(i) $\overline{\text{PRINT COMMAND}}$ falls from '1' to '0' at the end of each measurement cycle, indicating that a new reading has been transferred to the storage registers and is available as BCD output information

This line is a logic '0' except where the BCD information is being updated (a period of about 5mS) It can therefore be used as a data available indication to an external reading device.

A logic '0' on $\overline{\text{PRINT INHIBIT}}$ will disable $\overline{\text{PRINT COMMAND}}$.

(ii) $\overline{\text{SIGNAL INTEGRATE}}$ is a logic '1' when the A-D converter is sampling the input and its falling edge indicates that a new input may be applied.

(iii) $\overline{\text{HOLD}}$ is an input control line which when logic '0' stops the instrument from sampling in its normal free-run mode. When this line goes to '0' the instrument completes any reading in progress and stores and displays it. No further readings will occur unless an external read command is applied or until this line is returned to logic '1'.

(iv) $\overline{\text{COMMAND}}$. A '1' to '0' transition on this control line commands the instrument to take one reading immediately and is only effective when $\overline{\text{HOLD}}$ is a logic '0'. A $\overline{\text{COMMAND}}$ pulse must be at least 2μS duration.

(v) $\overline{\text{DELAY}}$. If this line is held at a logic '0' when $\overline{\text{COMMAND}}$ is applied, then the read command will automatically be delayed by a period of time equal to the settling time of the selected integration filter.

(vi) $\overline{\text{FP CONTROL}}$. A logic '0' input on this control line inhibits the front panel control switches PRINT INHIBIT, MANUAL and HOLD.

* Trade mark: National Semiconductors

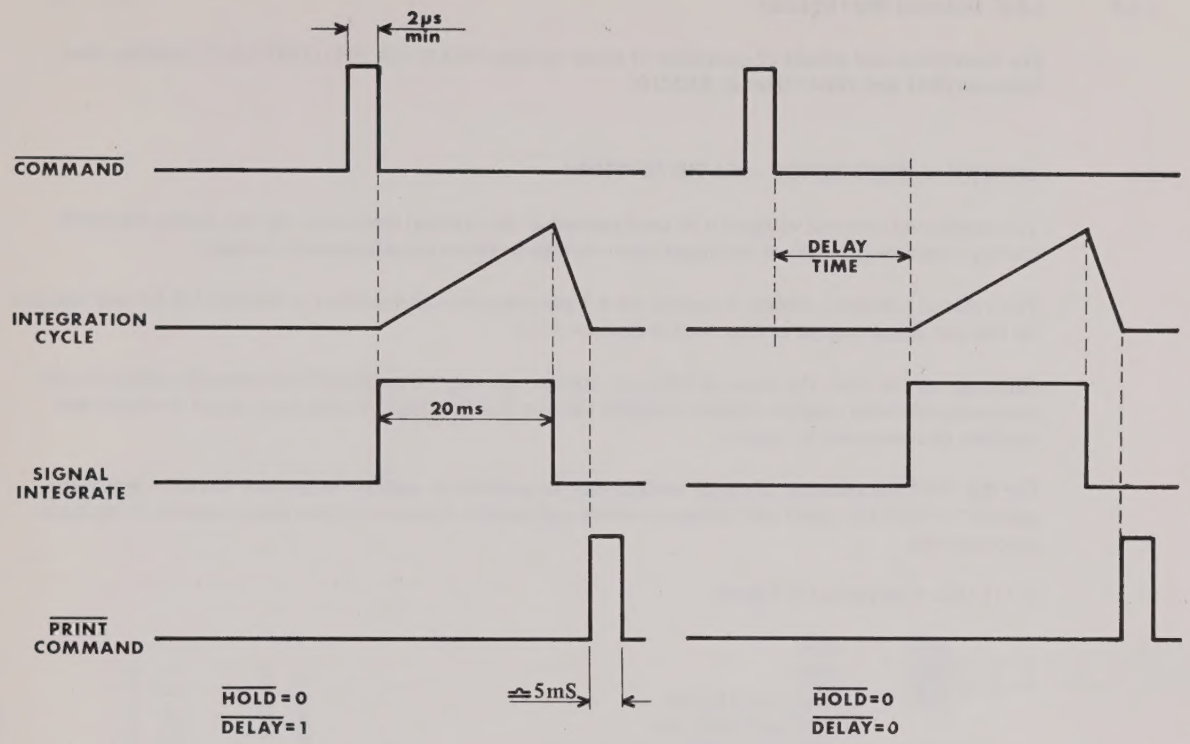


FIG 5.4 SYSTEM OPERATION TIMING

For maximum read rate in a closed-loop system, the command could be the falling edge of SIGNAL INTEGRATE as shown in Fig 5.5

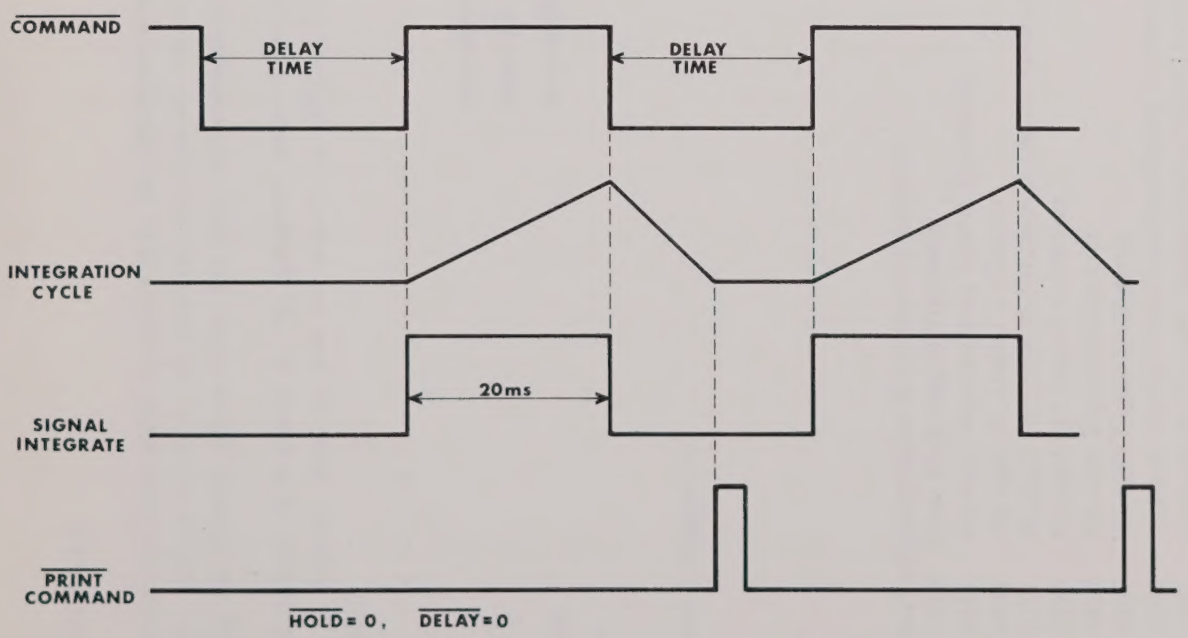


FIG 5.5 CLOSED LOOP SYSTEM OPERATION TIMING

5.5.3 I.E.C. Interface Bus (Option)

For description and details of operation of these options refer to the 1041/1051 I.E.C. Interface Bus Options (IB01 and IB04) Manual, 850210.

5.6 EXTERNAL REFERENCE – RATIO (OPTION)

This enables an external voltage to be used instead of the internal reference. By this means the DVM reading indicates the ratio of the signal input voltage to the external reference voltage.

The external reference voltage is applied via a 5-pin connector as described in Section 3.3.2.5 and selected via the rear panel control as described in Section 3.3.3.

Although on the 1041 the external reference voltage can only be positive it can normally perform ratio measurements with negative reference signals because it is floating from the main signal terminals and can thus be connected in reverse.

For the 1051 the external reference voltage may be positive or negative as internal circuitry senses the polarity of both the signal and reference inputs and enables 4-quadrant ratio measurements to be made automatically.

A 1:1 ratio is displayed as follows:–

R02	1.0000
R03	1.0000
R05	10.000 with 10 volts
	100.00 with 100 volts
R06	10.0000 with 10 volts
	100.000 with 100 volts

Thus to obtain the true ratio divide the reading by 10 if using the 10V option or by 100 if using the 100V option.